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RADIUM

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VOL. VII APRIL, 1916 No. 1

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A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES.

Edited and Published by Charles H. Viol, Ph. D., and William H. Cameron, M. D. with the assistance of collaborators working in the fields of Radiochemistry, Radioactivity and Radiumtherapy.

Subscription $2.50 per year, or 25 cents per copy in the United States and Canada in all other countries $3.75 per year.

Address all communications to the Editors, Forbes and Meyran Avenues, Pittsburgh, Pa.

VOL. VII. APRIL, 1916 No. 1

A REPORT OF THE WORK OF THE MANCHESTER AND DISTRICT RADIUM INSTITUTE.*

THE ROYAL INFIRMARY, MANCHESTER.

From January 1st, 1915, to December 31st, 1915.

ARTHUR BURROWS, M.D., RADIOLOGIST OF THE INSTITUTE.

The greater part of the energies of a new department working under complex conditions of inter-dependence with a number of different hospitals must, in its first year, be spent in organization and getting the machinery into running order. The scheme, however, seems now to be fairly started, and the staffs of the constituent hospitals are doing their best to make the Institute a success.

Owing chiefly to the war there have been difficulties in obtaining certain parts of the necessary laboratory apparatus, but these difficulties have been mostly overcome, and the physicist is now able to make all the apparatus essential for his own and for medical purposes.

The internal alterations effected in the building placed at the disposal of the Committee by the Board of Management of the Manchester Royal Infirmary have rendered the department convenient and compact. Owing to the necessity of obtaining the best natural light possible for the physical laboratory, it was necessary to make use of a somewhat small room having a north aspect. While adapted for all ordinary manipulations, it is felt that now that the routine has been fairly established a research laboratory suitably equipped might with great advantage be added to the Institute.

*In 1914, as a result of an appeal by the Daily Dispatch, a fund of over $150,000 was raised by public subscription for the purchase of radium for use in the Manchester (England) and district hospitals. A gram of radium element was secured and the committee appointed a radiologist, Dr. Burrows, and a physicist, Mr. Lupton, to carry on the work. This work is being carried on in connection with the Cancer Research Laboratory, under Dr. Powell White and his assistants.—Ed.

The greater portion of the medical work of the department has been the treatment of cancer in its various forms. This is quite natural when one considers the objects the founders of the Radium Fund had in view; but it is hoped that in the near future the treatment of a number of equally distressing, although not necessarily fatal, diseases will be undertaken by the Institute.

A report on one, or even two, year's work must, owing to the limited time which has elapsed, be an incomplete document, and all results recorded and experiences gained regarded with extreme reserve. The public are unfortunately prone to take an exaggerated view of what radium treatment is able to accomplish and to raise up hopes which cannot at present be realized, but steady work and improvement in technique will undoubtedly tend to secure in the future a gradual improvement in the results at present obtained.

In the treatment of cancer the difficulties remain many and grievous, and until a sure method is devised of checking the formation of secondary deposits, it will be possible in but few cases to claim cures.

The investigations of the Middlesex Hospital Cancer Research Laboratories on carcinoma and sarcoma occurring in mice and rats have suggested the possibility of producing immunity to cancer by means of radium, but no method of application or refinement of dosage has as yet been devised which will produce this result with certainty in human malignant disease. In a few cases the sudden and almost unexpected disappearance of a tumour, or such signs of reaction as high temperature, rapid pulse, &c., have suggested the formation of anti-bodies; but this experience is uncommon, and for the present we must look more for local than for general effects from radium treatment.

The practice of the London Radium Institute of treating only inoperable cases of cancer has been followed. All cases of malignant disease, except rodent ulcer, should, in the first instance, go to the surgeon and his opinion concerning the advisability or non-advisability of operation be accepted. Should he refuse to operate in a given case treatment by means of radium or X-rays should be considered. In certain border-line cases the use of radium may be advantageously combined with operation. One of the cases of carcinoma of the tongue, classified in Table I. under "prophylaxis," is an example of the value of this method. When the tongue had been removed tubes of "emanation" were inserted into suspicious situations. The patient is still well six months after operation. One case of sarcoma of muscle was also successfully dealt with by this method.

The department has carried on the treatment of tumours by embedding tubes of radium and radium emanation on a larger scale than has, it is believed, been customary heretofore in this country. In the case of large and deep-seated tumours, the results obtained by embedding are as a whole better than those obtained by the application of superficial flat plates. In a number of cases recorded in Table II. as "improved," the primary growth has entirely disappeared. Thus much pain and suffering have been saved, although secondary deposits, many of which have in their turn been diminished in size or have disappeared, have prevented the attainment of the result desired. The case of carcinoma of the colon, which remains well at the end of this year, is a good example of the value of this particular method.

Small tubes of emanation and occasionally of radium—the former has many mechanical advantages—are employed for implantation. They

are contained in cylindrical metal screens or filters to which silk threads are attached. The screens commonly employed are:—

(1) Tubes of silver, the walls of which are 1 mm. thick.

(2) Small tubes of platinum, the walls of which are 3/10 mm. thick. These are pointed and are of the type first devised and used at the London Radium Institute.

(3) Stevenson and Joly's needles: these are of the bore of small serum syringe needles. They are made of steel, and their walls are three-tenths or four-tenths of a millimeter thick. Originally they were left open at the ends and small emanation tubes fixed in them by allowing heated paraffin wax to run into their lumen by capillary action where it solidified as it cooled.

A modification of the needle has been more generally used in the department. Messrs. J. Woolley, Sons & Co., of Manchester, were able to make, according to instructions, a needle, the pointed end of which is solid and which can be screwed on or off, while the solid eyeleted end can also be dealt with in the same manner. The emanation tube can be introduced into the central cylindrical portion of the needle, while the screwed-in ends obviate the use of wax. In the same easy manner the emanation tube may be removed, and cleansing and boiling thoroughly carried out. Emanation tubes are made in lengths to fit the cavities, and there is no need to localize them once they are in the needle. In other respects the needle is identical with Stevenson's.

One or two other types of screen are occasionally used.

All doses of radium are expressed in terms of radium element, and the equivalent of emanation in "millicuries." This seems to be a more rational method than employing the commercial standard of radium bromide with its water of crystallization included, as the radium is the source of the rays and these rays are the agents employed in the usual method of measurement, viz., by means of the electroscope. The presence of other elements in combination thus becomes, except in a limited sense, a matter of no importance.

The following observations were made during the year with regard to the general facts to be borne in mind when burying tubes in growths or when deciding if a case is or is not suitable for the same:—

(*a*) Thorough aseptic technique is as necessary as in general surgery, because screened radium does not have a markedly antiseptic effect.

(*b*) Screens containing tubes of radium emanation may be boiled since the internal pressure of the heated tubes is as a rule well below that of the atmosphere. The boiling of tubes containing radium salts is not worth while on account of the risk of breakage.

(*c*) The object in radium treatment is to produce an adequate and even distribution of the rays throughout a tumour. Thus it is usually better to bury a number of weaker tubes in a growth than to employ one strong one for the same purpose.

(*d*) Accurate implacement of a tube in a growth is essential. It usually happens, therefore, that it is better to make a large incision and expose a tumour than to push tubes blindly through a small cut in the skin. It is moreover safer.

(*e*) It may be ignorance, but it has rarely so far been found possible to remove a cancer with one dose. This is a drawback which time may cure. At present, however, too big a dose may produce too violent a reaction with local necrosis of tissue.

(*f*) The reaction or ulceration after an overdose may last a long time, but never fails to settle down or to heal completely in the long run, with the following exception as noted in *g*.

(*g*) A growth treated by radium must be surrounded by or contain an adequate quantity of healthy tissue capable of supplying sufficient assistance for the work of repair, otherwise a permanent malignant ulcer may be formed. For example, the surface of the sternum or of a rib is a common site of recurrence after operation for removal of carcinoma of the breast. The nodule lies between the sternum and the stretched but impoverished skin. If it be treated by burying a tube of radium or emanation in its substance, it will be difficult to give a dose sufficiently strong to be effective. If it be large enough the nodule will probably break down and form an intractable progressive malignant ulcer. A similar dose administered to a superficial nodule in more healthy surroundings may produce no ulceration at all, or if it does, rapid healing will take place. It is better to attempt to treat recurrences situated in regions of low vitality by means of externally applied radio-active plates.

(*h*) The quantities of radium and radium emanation which should be used vary according to the size of the growth, the thickness of the screen employed, and the situation of the tumour. Some malignant growths appear to need larger doses per cubic centimetre than others; but to give a larger dose per volume in a case of, say, carcinoma of the tongue than is quite sufficient for a lymphosarcoma, is to take the risk of forming a slough of unpleasantly large dimensions.

When screens of 1 mm. of silver or three-tenths millimetres of platinum containing 20 to 50 millicuries of emanation are used, the usual exposure of twenty-four hours seems most often the best. Other and much shorter times have been suggested but do not seem to be so effective, at least in their local effects.

If Stevenson's needles be employed they should never contain more than 5 mc. of emanation, preferably 2—3, and should not be left in position more than twelve hours. One case of sarcoma of the upper jaw has been treated by these needles very effectively with exposures of twenty-four hours without signs of overdose, but this is an exception to general experience.

It usually seems, although conditions are so diverse that it is difficult to judge, that if a dose be doubled less than half the previous exposure will be needed to produce the same effect.

Speaking generally, tubes of 25 mcs. contained in screens of silver 1 mm. thick, or platinum 3/10 mm. thick, placed in a growth 2—3 cm. apart for twenty-four hours has been the most usual treatment given at the department, but it is obvious that every additional tube buried in a tumour must increase the total radiation traversing any given point in the mass, so that the aggregate dosage must always be considered. If we could find out exactly the amount of radiation therapeutically needed per cc. of a tumour, and an accurate method of estimating the size of cancer growths, there would merely be left to the physicist a mathematical calculation of the quantities to be used to produce total absorption, and the use of a sufficient number of tubes would remove the possibility of local overdose.

(*i*) In the treatment of malignant glands of the neck by means of radium, careful attention should be give to the toilet of the mouth. The presence of ulceration or of carious teeth may lead to septic infection of neighboring glands which in combination with enlargement of other glands, the result of the existing malignancy, may produce on the introduction of a radium tube definite abscess formation.

The majority of the cases treated during the year have been cases of rodent ulcer, and of carcinoma of the breast, uterus, rectum, and mouth.

The treatment of rodent ulcer continues to yield excellent results. Short, unscreened exposures (1—3 hours) of strong plates of radium are still the best method of dealing with them. In fact, falling back on the use of metal screens with longer applications is usually a sign of failure; although such a treatment applied at the beginning may be as successful as the unscreened method. Moreover it is unnecessary and less economical. Stevenson's needles are of material assistance, however, in clearing up certain ulcers with greatly thickened edges and deep induration. In fact, many cases which would otherwise have been regarded as hopeless have yielded perfect results following "needle" treatment.

To carcinoma of the breast practically the whole of the general remarks of this report apply. In a number of cases the primary growth has been removed by radium, and individual secondary deposits dealt with in the same way. Thus many of the painful and unpleasant features of the disease have been diminished, but usually a distant metastasis has in the end placed the patient beyond hope. If the growth be extremely large and widespread the same state of inability to repair is produced as in the case of a nodule formed in an unfavorable position.

The treatment of carcinoma of the cervix of the uterus has, on the whole, given good results. In dealing with such cases it has been customary to give a general anæsthetic. In this way a tube of 50 mcs.

of emanation contained in a screen of 1 mm. of silver may be placed accurately in the cervical canal. Usually its action is reinforced by inserting emanation needles in distant infected regions or in thick masses of the growth. Three or four small platinum tubes pushed into the substance of the cervix will produce an equally good result, but the method is not so economical. Fungating growths of the cervix yield most readily to treatment, while deep excavating ulcers with thick edges are less satisfactory. Invasion of the vaginal canal is an adverse sign. Four cases remain apparently quite well at the end of the year, and many more have had remarkable relief or complete absence of symptoms for six months or more.

Carcinoma of the rectum, owing to its situation, can only be treated by passing tubes of radium into the lumen of the growth. The presence of sensitive mucous membrane makes the use of a dense or thick screen (1.5 to 2 mm. of lead covered by rubber to cut off secondary rays) essential. For the most part the relief of symptoms is all that can be looked for. In one case in which the growth was unilateral a tube was introduced into the rectum and placed against its inner aspect, while another was pushed up through the perineum to the other side of the mass. In this way a cross-fire effect was produced. Unfortunately the patient did not submit to further examination, and no observation could be made.

Carcinoma of the mouth and tongue still gives unfavorable results, but one or two cases have done remarkably well. The only method of treatment which gives the slightest hope of success is implantation of tubes; external applications are practically useless. At present it is undecided if emanation needles with steel walls of 3/10 mm. thickness introduced into the growth for about twelve hours give better results than large doses of 30—40 mc. of emanation contained in pointed cylinders of platinum the walls of which are five-tenths mm. thick. If tubes of platinum three-tenths mm. thick are used, 15 mc. of emanation is quite a large enough dose.

Mr. Lupton reports that 585 emanation tubes, 257 emanation tubes for needles, 232 flat emanation applicators, and six special applicators were made during the year in the physical laboratory.

N.B.—This does not include the number of permanent radium tubes and plates.

During the past twelve months Drs. Powell, White, and Harris have prepared and reported upon 50 sections of various growths and morbid tissues submitted to them for microscopic examination. A number of other growths have also been examined at the Clinical Laboratories of the various hospitals participating in the scheme.

CLASSIFIED RESULTS.

TABLE I.

Free of disease at end of year	45
Improved	187
Not improved	123
Abandoned treatment	43
Died from their diesase	61
Too early to note result	51
Prophylaxis	9
Total	519

TABLE II.

Classification of Cases.

Disease.	Too early to note results.	Not improved	Improved.	Free of Disease at end of year.	Died from their disease.	Abandoned treatment.	Total.
CARCINOMATAS:							
Anus	—	—	—	—	1	—	1
Breast	8	22	34	—	9	7	80
Bladder	—	—	—	1	1	—	2
Cervix uteri	3	9	22	4	2	6	46
Colon	—	—	—	1	1	—	2
Ear	—	2	3	—	—	1	6
Glands	2	3	2	—	—	1	8
Jaw (upper)	1	1	2	—	1	—	5
Jaw (lower)	—	1	—	—	—	—	1
Larynx	—	—	—	1	2	—	3
Lip	1	—	2	—	—	1	4
Mouth-pharynx	4	17	12	—	4	1	38
Tongue	1	11	4	1	5	2	24
Tonsil	2	1	—	1	1	2	7
Naso-pharynx	1	—	1	—	1	—	3
Œsophagus	—	1	—	—	4	1	6
Orbit	—	1	1	—	—	—	2
Ovary	—	2	—	1	—	2	5
Paget's disease	—	—	1	—	1	—	2
Parotid and sub-maxillary glands	—	—	4	—	—	—	4
Penis	—	—	—	—	1	—	1
Perineum	—	—	—	—	1	1	2
Rectum	3	5	8	—	4	1	21
Scrotum	—	—	1	—	1	—	2
Skin (nose, ear, face, etc.)	3	7	4	4	—	2	20
Spine	—	—	2	—	1	—	3
Stomach	—	1	2	—	—	—	3
Thyroid gland	1	3	3	1	—	2	10
Vulva and vagina	—	4	1	—	1	—	6
Prophylaxis	6	—	—	—	—	—	6
Total	36	91	109	15	42	30	323
SARCOMATA:							
Glands	4	—	2	—	—	1	7
Jaw (upper)	1	—	1	—	1	—	3
Long bones	—	—	1	—	—	—	1
Muscle	—	—	2	*1	—	2	5
Naso-pharynx	—	—	—	1	1	—	2
Orbit (bony)	—	1	—	—	—	—	1
Palate	—	—	—	—	1	—	1
Periosteal	—	1	—	—	—	—	1
Popliteal	1	—	—	—	—	—	1
Pleura	—	—	1	—	1	—	2
Retro-peritoneal	—	—	—	—	—	—	—
Ribs	—	1	1	—	—	—	2
Supra-renal	—	—	—	—	1	—	1
Testis	—	—	—	—	—	1	1
Tonsil	—	—	1	—	—	—	1
Prophylaxis	2	—	—	—	—	—	2
Total	8	3	9	2	5	4	31
RODENT ULCER	8	12	26	24	1	2	73

**Combined with operation.*

CLASSIFIED TABLE OF CASES. TABLE II.—(*continued*).

Disease.	Too early to note results.	Not improved	Improved.	Free of Disease at end of year.	Died from their disease.	Abandoned treatment.	Total.
MALIGNANT TUMOURS:							
Endothelioma	1	—	3	—	3	—	7
Malignant glands	—	1	4	—	3	4	12
Lymphosarcoma	—	2	—	—	3	—	5
Melanotic sarcoma	—	—	—	—	—	—	—
Mediastinal tumour	—	—	1	—	1	—	2
Prophylaxis	1	—	—	—	—	—	1
Total	2	3	8	—	10	4	27
BENIGN TUMOURS:							
Fibroid uterus	—	—	1	—	—	—	1
Fibroma of hand	—	—	1	—	—	—	1
Fibro-adenoma of parotid gland	—	1	—	—	—	—	1
Certain tumours of doubtful nature	2	—	—	—	—	1	3
Papilloma of bladder	—	1	—	1	—	—	2
Glioma of orbit	—	—	—	—	1	—	1
Myeloid sarcoma	—	—	2	—	—	1	3
Papilloma, hard palate	—	1	—	—	—	—	1
Myxoma	—	1	—	—	—	—	1
Kraurosis vulvae et vaginæ	—	—	1	—	—	—	1
Capillary naevi	1	—	2	—	—	—	3
Cavernous naevi	—	—	3	—	—	—	3
Circoid aneurysm	—	—	1	—	—	—	1
Total	3	4	11	1	1	2	22
GENERAL AND SKIN DISEASES, CHRONIC INFLAMMATION:							
Arthritis deformans	—	2	—	—	—	—	2
Exophthalmic goitre	—	—	7	—	—	—	7
Eczema, Chronic	—	—	1	—	—	—	1
Granulomata of skin	—	—	—	1	—	—	1
Hodgkin's disease	1	—	3	—	1	—	5
Keloid and vicious cicatrix	—	—	5	—	—	—	5
Lymphatic leukæmia	—	1	—	—	—	—	1
Lymphangitis	—	—	1	—	—	—	1
Lupus vulgaris	—	1	—	—	—	—	1
Lupus erythematosus	—	—	—	—	—	1	1
Mastitis (chronic)	—	1	—	—	—	—	1
Metritis (chronic)	—	1	—	—	—	—	1
Macroglossia	—	1	—	—	—	—	1
Mucous colitis	—	1	—	—	—	—	1
Myositis (chronic)	—	—	1	1	—	—	2
Myeloid leukæmia (acute)	—	—	—	—	1	—	1
Oto-sclerosis	—	—	1	—	—	—	1
Pruritus	—	1	—	1	—	—	2
Pigmented mole	—	—	1	—	—	—	1
Spring catarrh	—	—	2	—	—	—	2
Sinus (chronic suppurating)	1	—	—	—	—	—	1
Tuberculous glands	1	1	—	—	—	—	2
Uterine hæmorrhage	—	—	2	—	—	—	2
Total	3	10	24	3	2	1	43

THE LIFE OF RADIUM*

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The life of radium, or the length of time required for a given quantity of radium to be transformed and converted into other elements, is a physical magnitude of conderable importance and interest. Its chief significance lies perhaps within the special field of radioactivity where radium occupies a unique position in being the only highly radioactive radio-element which possesses physical and chemical properties, and occurs in a sufficiently high state of concentration, to permit its being obtained in reasonable quantities in an isolated and purified condition. For this reason radium is considered and accepted as a standard or typical radioactive substance, and its physical and chemical properties, including the value of its atomic weight, are known with a considerable degree of precision. For some time in the future, therefore, radium will occupy this position of relative importance and will serve as the basis for calculation and comparison with other radio-elements possessing less striking chemical individuality.

An accurate knowledge of the life of radium is also important in the field of geology, because of a method which is available for estimating the geological antiquity of some of the older rocks and minerals The method is dependent on the determination of the progress of the radioactive disintegration which has taken place in those minerals containing appreciable proportions of uranium. For the accurate calculation of these important magnitudes an exact knowledge of the rate of disintegration of radium is essential.

It is possible, moreover, to obtain an estimate of the probable life of radium by a calculation involving as its basis a number of other important physical constants. These constants will be referred to more specifically later. If a knowledge of the life of radium can be arrived at by experimental methods not directly involving these constants, then, if the results given by the different methods are in good agreement, there is good reason for assuming that the accepted values for these constants are not very different from the true values.

The disintegration of radioactive substances is of such a character that the transformation of the substance into other elements can be expressed by a law in which the rate of transformation is an exponential function of the time. The rate of transformation is independent of the amount of material undergoing disintegration and is independent of the temperature, the pressure or of any other external condition to which we can subject the radioactive substance. It proceeds in such a manner that if half of the material present is transformed in a given period of time, half the remaining quantity will be transformed in a subsequent time of equal duration, and half the amount still left will undergo change in the third equal interval. This will continue indefinitely until the amount remaining will be too small to merit consideration. Since under these conditions some of the atoms of the radio-element will have an inappreciably short life, while others will have an inconceivably long one, it is impossible to attach any special significance to the term "life of" a radio-element except under certain definite restrictions. The life of

*Reprinted from Science, N. S. XLII, pp. 851-859, Dec. 17, 1915.

a radio-element may therefore be somewhat dogmatically expressed in terms of the time required for exactly one half of it to be transformed into other substances. This constant is known as its "half-value period," and it is the half-value period of radium which particularly concerns us at the present moment.

The first estimate of the probable life of radium was published by Sir Ernest Rutherford in the first edition of his text-book "Radio-activity" (Cambridge, 1904). In the disintegration theory proposed by Rutherford and Soddy the assumption was made that the expulsion of *a*-particles by radium and other radio-active substances was coincident with the changes taking place on the disruption of the atoms, namely, that the appearance of the *a*-particles was indicative of the simultaneous breaking up of the atoms of the radio-element. Rutherford further postulated the theory that each *a*-particle had its origin in the disintegration of a single atom, or in other words, that each changing atom gave rise to a single *a*-particle. If this assumption were correct, then an estimate of the total number of *a*-particles emitted by any radio-active substance would afford a basis for judging as to the number of atoms which underwent transformation in any given period. From the results of experiments by Wien on the number of beta particles projected from one gram of radium bromide, and from considerations based on the ionization produced in a gas by the *a*-particles emitted by a known quantity of radium, Rutherford reached the conclusion that one gram of pure radium element expelled 2.5×10^{10} *a*-particles per second. From data based on experimental evidence it was assumed that the number of molecules in one cubic centimeter of hydrogen at standard pressure and temperature was 3.6×10^{19}. Taking the atomic weight of radium as 225 it was then calculated that there were 1.8×10^{21} atoms in 1 gram of radium.[1]

If the total number of atoms present was 1.8×10^{21} and the number transformed per second was 2.5×10^{10}, then the fraction of the whole undergoing change per second would be 1.4×10^{-11}, and per year 4.4×10^{-4}. This indicated that the half-value period of radium was about 1,500 years.[2]

Another estimate of the life of radium was made by Rutherford in the Bakerian lecture delivered before the Royal Society in May, 1904. Assuming that the heating effect, which had been observed and measured by P. Curie in radium salts, was due to the bombardment of the salt by the *a*-particles emitted from the radium which it contained and concluding that heat energy which appeared was derived from the kinetic energy of the moving *a*-particles, Rutherford calculated the kinetic energy of a single *a*-particle on the basis of the data then available. This he found to be 6×10^{-6} erg per second. The heating effect of about 100 gram calories per hour observed for one gram of radium corresponded to 1.2×10^{6} erg per second. Considering the radium salt as containing four *a*-ray products (Ra, Ra Em, Ra A and RaC) and assuming an equal distribution of the heating effect between these, it therefore appeared that the number of *a*-particles expelled per second per gram of radium itself (and therefore the number of atoms of radium breaking up per second) was 5×10^{10}. Applying the same line of reasoning as had been used in the first instance for deriving

1—An error was made in this calculation, and the correct number based on the data used should have been 3.6×10^{21}. This would have given 3,000 years for the half value period

2—See preceding footnote.

the number of atoms in one gram of radium, Rutherford obtained the value of 800 years for the half-value period of radium.[3]

In the year 1905 Rutherford[4] performed an experiment in which the electrical charge carried by the *a*-particles from a known quantity of radium was measured. This was found to be equivalent to 4.07×10^{-9} ampere per second for the particles emitted by one gram of radium. Assuming the charge on each particle to be the same in value but opposite in sign to the charge carried by a single electron; viz., 1.13×10^{-19} coulomb, this gave the number of *a*-particles per second from one gram of radium as 6.2×10^{10}. Estimating, in this case without the previous error, the number of atoms in one gram of radium as 3.6×10^{21}, the value obtained for the rate of change of radium corresponds to a half-value period of about 1,300 years.

A new and more accurate determination of the deflection of the *a*-particles from radium in a magnetic and an electric field was made in 1906 by Rutherford.[5] This gave a value of 5.1×10^{3} for the ratio of the charge to the mass (e/m) of an *a*-particle. Since the value of e/m for the hydrogen ion in the electrolysis of water is nearly 10^{4}, Rutherford decided that of a number of possible explanations of these two differing values, the most probable one was that the *a*-particle consisted of an atom of the element helium (atomic weight 4) with a charge twice that of the electron. If this assumption is introduced into the last previously considered calculation of the life of radium, the number for the half-value period comes out 2,600 years instead of 1,300 years.

In 1908 Rutherford and Geiger[6] devised an experiment in which the actual number of *a*-particles emitted by a known quantity of radium could be accurately counted. They also accurately measured the charge carried by a known number of these particles, and demonstrated the correctness of Rutherford's earlier assumption that the charge on a single particle was twice that carried by a single electron. From the counting experiments it was evident that the number of *a*-particles emitted per second from one gram of radium was 3.57×10^{10}. The results of these experiments also gave data from which a more accurate estimate could be made of the number of atoms in one gram of hydrogen, viz., 6.2×10^{23}. Using the numbers thus derived the magnitude of the half-value period of radium was again calculated and found to be 1,690 years.

A direct determination of the rate of disintegration of radium by measurements of the decrease in radioactivity of a given radium salt is not practicable from an experimental standpoint. The rate of disintegration is so relatively slow and the experimental difficulties of accurately measuring the very small yearly decrease in the amount of radium present are so insurmountable that this method of attacking the problem is practically excluded. There is, however, a way in which a knowledge of the life of radium can be obtained which depends upon very different principles from those involved in calculations employed by Rutherford. This method was first suggested and applied by the writer, and its general principles can be briefly described as follows:

3—The error mentioned previously was repeated here, and the correct value given by this calculation is not 800, but 1,600 years.

4—Phil. Mag., 10, p. 193.

5—Phil. Mag., 11, 348.

6—Proceedings of the Royal Society, A, 81, p. 141; ibid., A, 81, p. 162.

The work of Boltwood, McCoy and others has conclusively demonstrated that radium is a transition product in the radioactive disintegration of the element uranium. The sources of radium consist solely of old minerals containing uranium. In these natural compounds the uranium has been undergoing transformation for long periods of time and the products of its disintegration have been accumulating and have been retained in association with the unchanged uranium in the mineral. Now the nature of the successive changes occurring in radioactive substances is such that, in any system such as that represented by a uranium mineral, after sufficient time has elapsed a comparatively simple relation will exist between the quantities of the different genetically connected elements present. The condition finally attained is known as a state of radioactive equilibrium. In this state a simple expression will define the relative amounts of the different, related radio-elements contained in the mineral, and, what is more important to our immediate interests, a very simple relation will exist between the amounts of the different radio-elements undergoing transformation in equal periods of time.

The rate of change of a radio-element is, so far as our knowledge extends, an unalterable and unvarying factor. It may be defined in terms of the fraction of the whole amount of the element present which undergoes transformation in any convenient unit of time, a year for example. This factor is called the constant of disintegration of the radio-element. Its character is such that if P represents the number of atoms of a radio-element initially present, e is the base of the natural system of logarithms, t is the time expressed in the chosen units, and λ is the disintegration constant; then the number of atoms, P_t of the element which will remain unchanged after the expiration of an interval t units from the start will be expressed by

$$P_t = Pe^{-\lambda t}.$$

Now, in any radioactive system comprising a parent substance like uranium and a series of disintegration products, including radium, for example, when a state of radioactive equilibrium has been established the conditions will be such that the number of atoms of each of the radio-elements in the series which undergo change in a given interval will be the same and equal. Thus if U be the number of atoms of uranium and λ_1 be its constant of change, and if Ra be the number of atoms of radium with a constant of change λ_2, then $\lambda_1 U = \lambda_2 Ra$, and this will also equal the product of the *number of atoms* of any other radio-element in the series multiplied by *its* disintegration constant. It should be evident from these considerations that the quantity (number of atoms) of radium formed in any given interval, will be equal to the quantity (number of atoms) of radium which is transformed in the same interval, an essential requirement to the postulated condition of equilibrium. If, then, we can determine by experiment the quantity of radium which is formed in such a system, we obtain through this a direct measure of the quantity of radium which has changed to other elements during the observed period, and if we know the amount of radium present in the system we can determine the ratio of the two amounts which will be the disintegration constant of the radium. If radium were formed directly from uranium it would be easily possible to separate the uranium from a quantity of mineral containing a known amount of radium, purify it

from all but traces of radium, allow it to remain until measurable amounts of radium had been produced within it, and then compare the radium formed from the uranium with the radium present initially in the mineral. This was attempted, but it was found that the rate of production of radium was too slow to be determined with any accuracy and was far less than was to be expected from theoretical considerations. This obstacle was overcome when in 1907 the writer was able to separate from uranium minerals a previously unidentified radio-element which was intermediate between uranium and radium in the series of atomic transformations, and which by its own disintegration produced radium in readily measurable quantities. To this element the name "ionium" was given. It thus became possible to separate the ionium from a mineral containing a known amount of radium, and to determine the rate of growth of radium in this ionium. This is a measure of the rate of production of radium in the mineral and therefore a measure of the rate of disintegration of the radium.

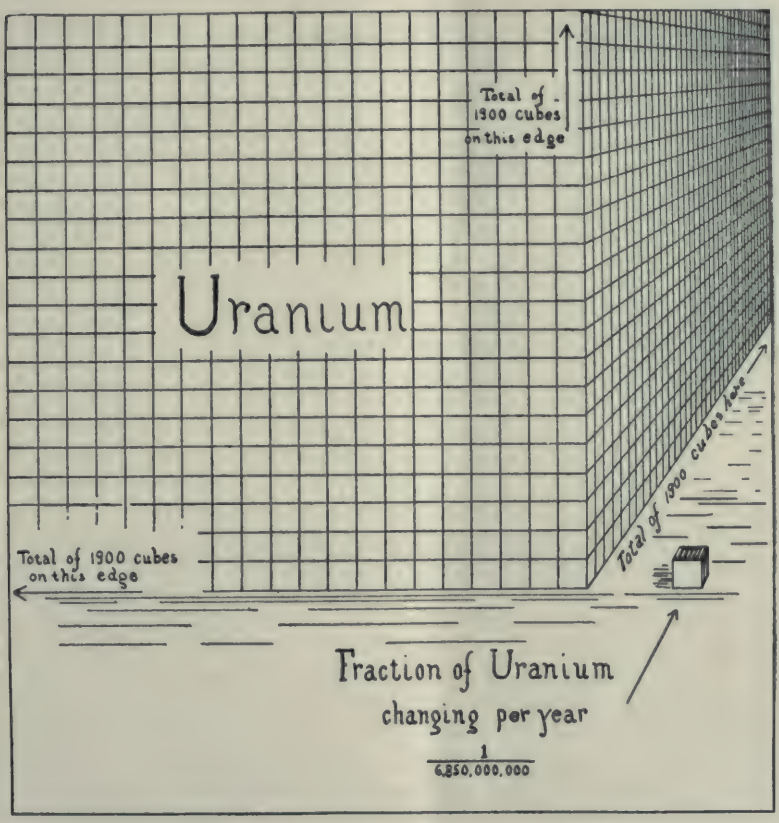

Figure 1

The two diagrams (Figs. 1 and 2) will perhaps be useful in making the general conditions and method of procedure more easily understood to those without a technical knowledge of the subject. In the first (Fig. 1) the amount of uranium changing per year relative to the total

amount present is shown by two cubes whose volumes are proportional to the number of atoms involved in the transformation. In the second diagram (Fig. 2) the first cube on the left is supposed to be of the

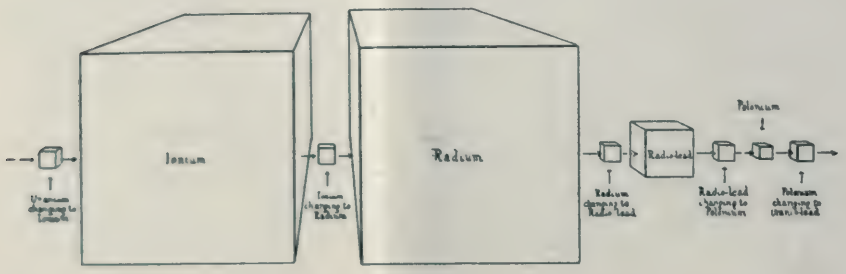

Figure 2

same size as the smaller cube in the first figure. Since the constant of change of ionium is as yet undetermined, it has been assumed for convenience to be approximately the same as that of radium, and the amount of ionium in the mineral is therefore indicated as of the same order as the amount of radium. With this limitation, and omitting the slight complications involved by the existence of branch products, like actinium, and products of a rapid rate of change, like the emanation and radium-A, the diagrams represent the general conditions and changes to be found in an old[7] uranium mineral. The chief relation of interest shown by the diagram is that since the radium changing to radio-lead can not be determined experimentally with sufficient exactness, it is equally satisfactory and very much simpler to determine the ionium changing to radium and compare its quantity with the total amount of radium in the mineral. As a matter of fact the actual amounts of radium involved in these two quantities need not be known, it is only their relative values which are required, since the value of the disintegration constant is determined by the ratio of one of these to the other. In this respect the method is independent of any standard of purity of radium preparations, an advantage which is not possessed by other methods which have been used for attacking the problem. Thus, for example, the estimate of the half-value period of radium made by Rutherford and Geiger as a result of their experiments in 1908, had to be altered from 1,760 years to 1,690 years, when in 1912 the present international radium standard was adopted.

The results of a number of experiments conducted by the writer according to the method just outlined were published in 1908. In the most satisfactory of these experiments the mineral taken was a quantity of pure, primary North Carolina uraninite, almost free from secondary alteration products. About 40 grams of this material were used and the ionium was separated (with the thorium, which has identical chemical properties) by the ordinary analytical methods for the separation of

7—There are well known examples of minerals too young for a state of equilibrium to have yet been reached between their radioactive constituents.

thorium. The growth of radium in this preparation of ionium was then measured over a period of 147 days, and a rate of change for radium corresponding to a half-value period of 1,990 years was obtained. The results of the other experiments were in fair agreement with this value, which was assumed to be the most probable one. It is interesting to point out that this estimate was made between the time of Rutherford's estimate of 2,600 years and Rutherford and Geiger's estimate of 1,760 years.

In view of the disagreement of the value obtained by the "growing" experiment with the value as calculated from Rutherford and Geiger's work, it was reasonable to suspect that in the "growing" experiments all of the ionium was not separated from the mineral. Such a suggestion was, in fact, made subsequently by Rutherford. A careful investigation of some of the conditions associated with the usual methods, employed for the chemical separation of smaller portions of thorium from large amounts of uranium, indicated that a complete separation of the thorium under such conditions was extremely uncertain if not altogether impossible. The chemical behavior of uranium and thorium is strikingly similar: in the case of the uranous (UO_2) salts the chemical analogy of the two elements is such a close one as to make any separation at all almost impossible. Since an incomplete separation of the ionium would lead to *too small* a production of radium in the growing experiments, under the assumption that the separation was complete the calculated half-value period of radium would receive too high a value. It was therefore highly desirable that the experiments should be repeated under conditions which would avoid any uncertainty, and which would give an altogether trustworthy value for the life of radium as determined by this method.

This work was undertaken in the university year 1913-14 in my laboratory by Miss Ellen Gleditsch, who came to this country from Norway for a year of study on a fellowship of the American Scandinavian Foundation. The work has been carried out in a very satisfactory manner and, after encountering a number of difficulties, she has quite recently completed her experiments at the University of Kristiania. A paper by her on the subject will appear in the January number of the American Journal of Science.

Miss Gleditsch carried out four separate operations, which may be briefly described as follows:

The *first* was with a specimen of very pure North Carolina uraninite weighing 110 grams and containing 2.46×10^{-5} gram of radium. The growth of radium from the ionium separated from this material gave a value for the constant of change of 3.7×10^{-4} (per year), which corresponds to a half-value period of 1,836 years.

The *second* was with a specimen of Norwegian uraninite known as Cleveite, weighing 180 grams and containing 3.2×10^{-5} gram of radium. The ionium separated from this material grew radium at a rate corresponding to a value for the constant of 3.9×10^{-4} and a half-value period of 1,780 years.

The *third* was with a specimen of Norwegian uraninite of the variety known as Bröggerite, weighing 200 grams and containing 4.1×10^{-4} gram of radium. In this experiment the radium grew at a rate corresponding to 4.2×10^{-4} for the value of the constant and indicated a half-value period of 1,640 years.

In the *fourth* experiment a specimen of very pure Bröggerite was

used, weighing 100 grams and containing 2.1×10^{-5} gram of radium. The value obtained for the constant of change of radium was 4.1×10^{-4} and the half value period corresponds to approximately 1,670 years.

In this series of experiments the methods for effecting a complete separation of the ionium were progressively developed and improved. In the last two, the ones in which bröggerite was used, there were definite indications that a complete separation had been accomplished. Moreover, Miss Gleditsch also measured the amount of radium in one of my original ionium solutions in which the radium had been growing for a period of nearly seven years and found that the rate of growth had been constant throughout the entire interval. This fact disposes of the possible objection that the life of ionium is too short to give an accurate value for the constant of radium as determined by this method.

It is therefore apparent that the different methods which have been used for esitmating the life of radium give results which are in excellent agreement with one another. This agreement increases the assurance with which the estimated values of certain important physical constants involved in the calculation can be accepted as approximating closely to the true values. As a matter of interest these constants will be mentioned.

Number of α-particles emitted per second by one gram of radium (element) $= 3.57\times10^{10}$.

The charge carried by a hydrogen ion in electrolysis $= 4.65\times10^{-10}$ E.S. units.

The number of atoms in one gram of hydrogen $= 6.2\times10^{23}$.

The mass of the hydrogen atom $= 1.61\times10^{-24}$ gram.

The number of molecules in one cubic centimeter of any gas at standard pressure and temperature $= 2.72\times10^{19}$.

The volume of the radium emanation in equilibrium with one gram of radium $= 0.62$ cu. mm. calculated, $= 0.63$ cu. mm. found.

The rate of production of helium per year per gram of radium $= 163$ cu. mm. calculated, $= 164$ cu. mm. found.

REVIEWS AND ABSTRACTS.

Evan O'Neill Kane, M.D. (Kane, Pa.) Radium Therapy. Abstract of a paper read at the Annual Meeting of the Elk County Medical Society, January 13, 1916. "While the radium subject has been of interest to me for some time, and while I had had it directly under observation as it was employed by Doctors Burnam and Kelly, of Baltimore, and Doctor Lee, of Rochester, I did not possess any myself until about seven months ago."

"I have treated forty-three cases of cancer, with four deaths, and employed radium for other conditions for about as many patients. We all have our share of unfortunate incurable cancer cases to deal with. I have certainly had mine, and last winter I was satisfied that more than my share fell to my lot. It was one of these which drove me to my purchase of radium. The case was one of cancer of the uterus with involvement of both ligaments, bladder and rectum. I had been asked

by a brother practitioner to remove the uterus despite the fact that the termination of the case must be hopeless, trusting that thereby temporary relief, at all events, would be afforded. As often happens in these cases, an apparently complete recovery took place, pain being relieved, and the patient regaining her former strength, cheerfulness and usefulness. It was acutely distressing to realize that she must die, especially as she put complete trust in me and showered me with grateful expressions for saving her life. As the disease began to make itself apparent again, with renewed activities in bladder and pelvic walls, I was so distressed that I hated to visit her. The truth had to come, and I had to break it; we all know how painful that is. I looked about in desperation for some quasi-assurance of relief to take off from the poignancy of her grief on learning her true condition. Having talked with her husband and receiving his consent, I told her that I had observed that Dr. Lee, of Rochester, was apparently making remarkable cures with radium in such cases as hers, and suggested her going to him. Of course she consented and went. She remained in his sanitarium but one week, and two weeks later came to me for examination. To my astonishment the entire cancer mass had vanished. There was not a vestige of it to be discovered. Vaginal vault, bladder and rectum were soft, flexible, and apparently sound, and no lymphatic enlargements or cellulitic cakings could be detected anywhere. She was entirely free from pain, well and happy. It seemed to me miraculous, and precipitated my purchase of radium."

"To anticipate your question as to what next in this case, I will go on and tell you the truth and the whole truth. Three months' of freedom from pain elapsed, and then she came to me complaining of pain far back in the sacral region—something like a dull backache. Vaginal examination disclosed a suspicious hardening well up and back towards the sacro-iliac junction, not as large as a hazel-nut. I again sent her to Dr. Lee, who returned her to me after having melted this new formation away with his radium as satisfactorily as before. A month later, however, she began to have trouble with her bowels, vague pains, gas trouble, and constipation alternating with diarrhea. She commenced to lose flesh and show signs of stomach indigestion, eructation, vomiting and the like. Complaining of constant pain at her appendix, I thought this might be the cause, operated, and found the lower abdomen, and even as high as the umbilicus, studded everywhere with metastatic beads, proving a general cancerous infection. A little later rectum, vagina and bladder became the seat of renewed malignancy,—and so the old story was told anew, of death from cancer."

"I cite this case in full not merely to show you why I purchased radium so hastily, but because I wish to give you in fairness an example of the cases in which radium does not cure."

"One case, referred to me by Dr. Smith, of Johnsontown, of cancer of the rectum, is, I think, still in a doubtful condition, but I have not heard from him recently. In this instance, however, the cancer mass, which filled the entire rectum, involving, also, the anus and extending out well towards the ischial tuberosities, was so extensive as to make it appear out of the question to do anything. Yet, within a month after treatment was begun, no cancer masses were discoverable anywhere. The radium burns, however, were extensive, and in order to institute the treatment properly I had been forced to make an inguinal colotomy. The discomfort from this, as well as from the burns, was considerable when

I last saw him, about six weeks ago, and made it impossible for me to say positively whether cancer trouble further back might not still be present. He was, however, far better off than before he came under treatment."

"Now, as for my successful cases, time will not permit my going into detail with all of them. I will mention, however, the most striking. Five of these were inoperable cases of cancer of the uterus, with involvement of broad ligaments, bladder and rectum; and four cases in which, the cervix was involved, with suspicion of the body being also, but in which there was no discoverable evidence of extension further. All appear to have recovered entirely, and have regained flesh and strength, —are looking and feeling well. Five are cases of face cancer, in three of which there was involvement of the lymphatic glands of either temple, neck or jaw. Two of these are still under treatment, but appear to be rapidly recovering. The others seem entirely well. One of the face cancers, sent me also, by Dr. Smith, was of the lower lip with some glandular involvement just below the jaw. One case of cancer of the tongue, tonsil, soft and hard palate, with extension to the glands of the neck, referred to me recently through Dr. Glenn, of Bradford, has only been under treatment about six weeks. In this case the glandular mass in the neck, which was very large, has melted down to one-third its size. While the burns in the mouth are painful, the tonsil involvement and original tongue cancer have melted away so much that the man can now swallow with reasonable comfort, and talks fairly intelligibly, while at first both talking and swallowing seemed painfully difficult. How far he will continue to improve I cannot say."

"A case of cancer of the tonsil, involving the palate, root of the tongue and much of the upper pharynx, referred to me by Dr. Balmer, of Brookville, had been declared inoperable by Crile, and was also a severe diabetic. Under radium he made an apparently complete recovery, being enabled to return to his business in Washington. I have heard recently that he is ill, but I presume that is from his diabetes, for which he had several times, before coming to me, had to resort to sanatarium treatment."

"A very interesting case still under treatment, or rather observation after treatment, and certainly a very rare one, is that of an old man in his 103rd year. This patient has a large cancer of the orbit, with extension to the lymphatics of the temple. The cavity was eaten out so deeply as to suggest that the eye had totally disappeared. Examination, however, proved that this organ had shrunken into a small lump and been drawn by tissue contration in under the inner border of the orbit. The cancer had existed between 18 and 20 years, and had, at the time I took charge of the case, become so painful as to require the nightly use of anodynes. Dr. Briggs, of Tidioute, who referred the subject to me, did not expect that I could do much, if anything, for him; but, knowing that I was interested in cancers, wrote me that he thought the case worth my visiting in the light of a curiosity. I began treatment promptly, subjecting not only the cavity to radium, but also the nodular involvement on the temple. The first gratifying results were the cessation of pain, no further opiates being needed, and the restoration of sound and natural sleep. The side of the face swelled dreadfully, becoming edematous and purple. I feared that, his age being great, he would not have sufficient vitality to outlive the radium reaction, which is violent. It took him a long time, but the reaction has

entirely passed away. The nodular extension in the temple has disappeared, the orbital cavity is filling with apparently healthy granulations, and a healthy contraction of the whole area is taking place, with adhesions of the marginal skin to the granulations wherever they reach its border. Thus far, however, no distinct epithelial proliferation has commenced. Whether this is possible at so advanced an age I am not aware. I am preparing, if he continues to favor me by living, to place skin grafts from a young subject in the filled up crater. In this instance I am satisfied that I have cured the cancer, but whether it is possible to bring about a healthy healing remains to be seen." Note Feb. 2nd, 1916. "This case has now so far improved as to now have the raw tissue rapidly skinning over. This seems marvelous at any age to say nothing of one-hundred and three!"

"More satisfactory to me than the treatment of my cancer cases has been that of uterine fibroids. Several authorities, I observe, claim that but 75% of uterine fibroids are amenable to treatment with radium. Thus far all mine, nine in number, appear to be on the mend. All but one of these were, in addition, ugly cases of flowing. Flowing in every instance was entirely checked, and the fibroids have been steadily reducing in size, so that I feel satisfied that operation will be unnecessary. In several other instances, with flowing, but without demonstrable fibroids, the hemorrhage has been satisfactorily checked."

"I had hoped to treat a large number of goitres with radium, supposing that patients would prefer this mode of removal to operation, and having seen some very gratifying work done by others. I have not had, however, in all more than eight or ten subjects willing to allow me to employ the radium treatment, nor have these been long enough under observation to be worthy of report. I must say, however, that they all seem to be improving,—that is, a reduction in size of the gland has in every instance taken place. I have only one case of exophthalmic goitre under treatment, and this but six weeks. The pulse rate is markedly reduced, the nervous tremor has disappeared, and the patient admits herself to be feeling better."

"The lighter superficial work with radium placques on skin cases appears to open a field of wide use for smaller amounts of radium. I had admirable results in curing a large port-wine stain birthmark of the arm by a 10 milligram radium placque; and have also cured a large vascular naevus of the nose and lip in a baby with the same placque. Warts, moles and keloids are entirely removed by it. The keloids, however, require a number of treatments, and I question whether the moles and warts are not as well and more rapidly removed by trichloracetic acid. The latter agent, however, has the objection of being painful."

"You may ask, "Does radium treatment occasion any pain?" No, not during the treatment, nor often for weeks—sometimes four or five—thereafter. Then there is frequently a sharp reaction, a burn resulting even after screening. There is also a constitutional reaction in many instances where a deep malignant growth has been subjected to prolonged treatment."

"How do the burns get along?" Usually they heal rapidly and occasion a surprisingly small amount of pain or discomfort, but in a few instances (three in my brief experience) a deep scirrus-like sloughing ulcer results, which is slow and painful in healing. I am told these are due to over-radiation, and could be avoided if one had not been unduly hasty."

"What is the probable proportion of permanent cures as compared with relapses? I am not in a position personally to answer this, but as a large proportion of the subjects treated have been already allowed to pass into the cancer cachexia stage, I should presume that the number of relapses will be found to largely outnumber the permanent cures. At the same time, no one who has experienced the satisfaction of employing radium will, I am sure, ever be satisfied to do without it."

"Shall radium be employed in conjunction with the knife before or after it when dealing with malignant neoplasms? Surgeons, as a rule, if they admit the efficacy of radium at all, claim that it should only be employed as an adjunct to the knife. I thought so at first, but begin to question seriously the correctness of this opinion. If one can be sure that his knife has gone well beyond the area of contamination he may with propriety operate, thus removing center and circumference, the whole source of mischief. Thereafter, indeed, radium may be employed to ray the outlying tissues and purge them of any possible undetected secondary centers. It might, on occasion, be justifiable to use radium in these same areas before resorting to the knife in order to build up a barrier of cancer resistance. These may be reasonable assumptions, but, as a rule, I believe it will be ultimately admitted that if radium has, as we radium workers believe, a selective action directed against cancer cells and their development it should be given a first place in the treatment of malignant disease, and thereafter the knife employed only as a dernier resort."

"The obvious objection to the knife in dealing with cancers has been clearly demonstrated by Dr. Percy of Galesburg, in his heat treatment of malignant diseases. He has shown beyond question that the knife stirs up and drives into the lymphatic and blood stream the cancer cells, against which nature has been previously able to oppose at least a partial barrier of resistance. As a result extensions and metastases take place with alarming rapidity in the majority of cases. Percy, therefore, condemns the cold knife in toto, saying that if operation must be resorted to it should be only by a knife heated to redness, that it may cook the tissues through which it passes before dividing them, thus continuously setting before it a defense against cancerous progress. His theory has been borne out by practice, and he has obtained remarkable results. On the same principle radium, and, to a certain extent, the X-rays can do for cancer what Percy's heat treatment does, only, I believe, with less danger from destruction of tissues, as well as with less pain."

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S. E. Sweitzer, M.D. (Minneapolis). Radium in Dermatology. The Journal-Lancet, Vol. XXXV, No. 24, pp. 679-83. "Radium was first used in dermatological work. The use of the rays was brought about by Becquerel, who put a tube of radium in his pocket, and a burn resulted. This drew attention to its action upon the skin, and Professor Curie gave a quantity to M. Danlos, of the Hospital St. Louis, and experiments were begun upon cutaneous therapy."

"Radium occurs in nature associated with barium. The radium element itself is very difficult to obtain alone; and therefore it is used in the form of a radium barium salt."

"For cutaneous work radium is used in flat varnish-applicators, which have a metallic back, and are usually square. The radium is evenly distributed over the surface, and covered with a varnish. These applicators are prepared in full strength, half strength, and quarter strength. A full-strength applicator contains 5.4 mgm. of radium element per square centimeter of surface; a half-strength applicator contains 2.7 milligrams of radium element per square centimeter of surface, and a quarter-strength contains 1.35 milligrams per square centimeter. I have found a half-strength applicator containing 10 milligrams of radium element most serviceable for general cutaneous use."

"It is important to know how much radium is used, how screened, the length of time used, and the total time used. Merely to say that 'I cured a Roentgen-ray carcinoma with radium,' as has recently been done, not stating the amount used or the time applied, is of little help to others. Generally speaking, when a large quantity of radium is used a shorter time is necessary to produce a given effect than if a small quantity is used."

"Radium gives off alpha, beta and gamma rays. The alpha rays are cut off by the varnish in the applicator. We use the beta and gamma rays. The gamma rays are many times more penetrating than the ordinary Roentgen ray, but the new Coolidge tube gives off rays that approximate the gamma rays of radium."

"It has been found that using the radium without any screen or filter is irritating to the skin, and may produce telangiectasis; and therefore we interpose filters of different metals in varying degrees of thickness, according to what extent of rays we wish to cut out. As the radium in contact with these various metals causes them to give off secondary rays, which are irritating to the skin, we cover these screens, or filters, with several layers of black photographic paper, and outside of this a piece of rubber dental dam."

"In order to protect the healthy skin, if the lesion is smaller than the applicator, I use about five or six thicknesses of ordinary lead foil, and cut it out to fit the lesion to be treated. A piece of dental dam is placed under the lead next to the skin to avoid the secondary rays. I hold the protector on by means of adhesive strips, and then place the radium over the lesion and fasten it with adhesive."

"When radium is used on the skin, we get reactions of varying degrees of intensity, such as (1) simple erythema; (2) erythema followed by desquamation; (3) vesiculation with superficial ulceration; (4) deep ulceration with the formation of a scar. These reactions depend upon the amount of radium used, and the filter and the length of time used. Pusey says that the manifestations of a radium reaction are first seen in the endothelium of the superficial vessels, almost as soon as in the epithelium of the glands of the skin; then in the deeper epithelial layer; and, finally, in the connective-tissue structure of the skin. It exerts a selective action upon diseased cells; and in this manner they are destroyed, and the healthy cells left."

"Radium has been used in a large number of skin diseases. I will touch upon its use in pigmentated and capillary nevi, lupus erythematosus, and epithelioma, as I have found it especially valuable in these conditions."

"In raised pigmented nevi a dose sufficient to produce a slight crusting is used. I use a ten-milligram applicator screened with 0.1 mm. silver for thirty minutes. This can be done two or three times with two-day intervals."

"In capillary nevi I use a screen of .01 mm. of aluminium, giving applications of fifteen to twenty minutes. After the reaction is over, this can be repeated until the desired result is obtained. In a few cavernous angiomata of children I have proceeded with a screen of 0.1 mm. silver, using about the same dosage as for the elevated pigmented nevi. In general, I have found the cosmetic results excellent. It must be remembered, however, that we must make haste slowly; and many months must elapse before a cure is completed. Too large or insufficiently screened doses will produce a white scar, instead of normal-looking skin."

"CASE-REPORTS OF TWO CURED CASES."

"Case 1.—Baby L., aged 3 months. Angioma the size of a marble on the right cheek. November 9, 1914, radium screened with black paper (I was unable to obtain the .01 mm. aluminum filter at that time) used for 20 minutes. A slight reaction resulted, and some flattening occurred. November 30, 1914, the same screening, radium used for 30 minutes, with slight reaction and shrinking. January 11 and January 15, 1915, I used a 0.1 mm. silver filter for 30 minutes. February 26, 1915, the same dose was given. Seen on April 6, 1915, the result was fine."

"Case 2.—Baby Lundquist, aged 3 months. Large elevated pigmented nevus behind the right ear. November 4, 1914, radium 10 minutes; November 21, 30 minutes; December 29, 30 minutes; February 24, 1915, 35 minutes."

"These were all screened with black paper. April 12, 14, 16, 1915, radium was used for 30 minutes with a screen of 0.1 mm. siver. On May 21, 1915, the baby was seen and the result was excellent."

"Lupus erythematosus is a most intractable disease; and numberless remedies have been recommended in its treatment."

"Simpson reports a number of cases treated with radium with excellent results. I have treated only a few cases. One is nearly cured at the present time, and the others are too recent to report results. It does not prevent recurrences; but in favorable cases good results may be expected."

"It is necessary to use destructive doses; and filtering is indicated to prevent excessive reactions. I use a 0.1 mm. silver filter, and ray one hour a day for five or six days. It is often necessary to repeat this dose; and sometimes I have found it better to use radium unscreened in cases that are very intractable. My results have been promising, but the treatment is of necessity very tedious."

"Epithelioma, as is well known, responds beautifully to radium, often curing where the Roentgen rays have failed. I first treated these cases with radium unscreened; but I have found a deeper penetration and less reaction by using a 0.1 mm. silver screen, and ray for one or two hours a day for a total of eight or ten hours. My results have been most excellent."

"A CASE OF EPITHELIOMA."

"One of my early and most interesting cases was Mr. M., aged 77. He had an extensive rapidly growing epithelioma on the left side of the nose, the left cheek, and the upper lip. It was not an operable case."

"In October, 1914, I gave him an unscreened exposure of an hour a day for four days. It required three applications of the radium at each sitting to go over the lesion. In five weeks this was repeated; and

in January, 1915, one small spot was still active, and therefore I used a 0.1 mm. silver screen, and gave an exposure of seven hours. To date he has remained well and the cosmetic result is all that we could ask for. I would treat such a case now entirely with a screen, in order to limit the reaction."

"CONCLUSIONS."

"1. Radium has a definite value in the treatment of certain skin conditions."

"2. It is easily controlled, and is of accurate dosage."

"3. Its application is unattended by pain, and is very pleasing to the patients, especially the young and very old."

"4. The cosmetic results are excellent."

* * * * *

C. Everett Field, M.D. (New York). Radium. Its Physiochemical Properties Considered with Relation to High Blood Pressure. Medical Record, Vol. 89, pp. 135-139, January 22, 1916. Presented before the Washington Heights Medical Society, at New York, November 23, 1915.

"To have the radium situation clearly before our minds, we must acknowledge that much of the early experimental research with radium had many of the hindrances common to the study of so rare and new an element. The theories relating to the causative features of high blood pressure are many; but for our immediate need we care not to debate now whether it is due to a hyperplasia of the suprarenal capsule or, according to the old theories of Cohnheim and Traube, to mechanical interference in the flow of the blood stream, for we may content ourselves in the belief as clinicians that faulty ferments of toxic origin are the basic factors."

"From the earliest experiments to the present, lowering of high blood pressure during radium treatments has been the common report. Physiochemical processes are exact and the physiological and biological manifestations that follow must to a similar degree, be definite. Therefore it is that, in almost 95 per cent. of the high blood pressure cases treated, certain improvements are promptly noted, precordial distress, headache, vertigo, disappear at times even with small dosage. The general energy of the heart is markedly improved, and peripheral resistance is reduced. A factor that by some has been discounted is the viscosity of the blood; yet a change in type exerts an enormous influence of the arterial system—under emanation it is rendered less viscid. The elasticity of the muscular wall of the artery relieves the heart of much unnecessary load. When the tonicity is low, increased tension results. Radium emanation improves the general muscle tone of the entire system. All these processes naturally are the outcome of the influence of radium on the various ferments that may be disordered."

"I am frequently asked the question, 'Just what can we hope for clinically?' Recognized early, metabolic processes may be promptly improved, with the hope of a permanent cure. We have a right to assume that the process of hypertension can be checked so as to prevent the development of a nephritis. Indeed, I feel that there is a reason to believe that Bright's disease as a symptom may be wiped out. When nephritis and cardiac lesions are advanced, the pathological processes

can surely be held in check and life in a measure conserved; while at the last stake with a broken compensation we may sustain the patient by lowering tension, building up resistance, increasing somewhat the elasticity of the blood vessels, thereby lessening the danger of their rupture and materially adding to the comfort of the patient."

"*Administration.*—Radium may be administered by means of emanation inhalation, radioactive waters for drinking, solutions of radium salts for drinking, by means of emanation baths, or by intravenous or subcutaneous administration of radium bromide or radium chloride. Wherever dosage in micrograms of radium salts is quoted it refers to *radium element*. Radium has absolutely no toxic effects, it being accepted as harmoniously by the human system as is sunlight by the plant. The classification of clinical and dosage data reported by Rowntree and Baetjer is of considerable worth. Dosage in radioactive or emanation water is being used in variation of from 1000 to 1,000,000 mache units, and the pure radium element in the form of radium chloride has been administered intravenously in dosage as high as 1000 micrograms or the equivalent of 2,700,000 mache units in one dose without any untoward effects. With radioactive waters, von Noorden found but little results until his dosage of water approximated 20,000 mache units daily. The usual dose of radioactive or emanation water used by the London Radium Institute gives a minimum of 250,000 mache units daily and a mamixum of 1,000,000 mache units. Proescher and Cameron have made over 2000 intravenous injections of radium chloride in doses averaging 50 micrograms, and my personal observations cover the administration of over 800 similar treatments, and I find no report of any unpleasant effects. That radium is not permanently deposited, and that it is finally eliminated from the system is well covered in a research by Seil, Viol, and Gordon, who showed the character of complete elimination and its duration in the human. Most interesting research is now being done in measuring the radioactive content of the blood for weeks following treatment. The activity of radioactive waters is of short duration and consequently they are limited in their application. It is probable that no emanation can be traced two hours after taking, whereas radium solution by mouth can be traced and measured up to the sixth day. Following an intravenous injection of radium chloride it can be traced in the blood at least twelve weeks thereafter. Some of the earliest of injections of radium element were made by Brill, Falta, Freund, Zehner, and von Noorden. The latter reported no disturbing effects and urged larger doses and deeper study."

"So far as dosage is concerned in high blood pressure we are largely governed by the chronicity of the case and the involvement. Personally, I feel my best results have been shown in what we would term low dosage. Delano of Boston, has checked up some exceedingly important findings derived with low dosage. He has found his average dose to be 4 micrograms daily. It is my usual plan to give an injection of one 25-microgram (radium chloride) ampulle (2 c.c. normal saline solution), and following with a solution of distilled water, 2 oz., containing 2 micrograms of radium, given by mouth as one dose three times a week. After four weeks this drinking solution is cut to two doses per week. While the results are prompt, I never accept a case for less than twelve to sixteen weeks' treatment and observation. Careful histories of the laboratory findings are always to be made. The

patient may or may not be placed on diet and other rules of hygiene as may seem indicted. In private cases I would of course observe the above, in others I have preferred to watch the results without special or rigid diet. Under such a treatment we have a right to expect by far the large majority of cases of systolic pressures (running from 160 mm. to 200 mm.) to be influenced to drop from 15 mm. to 40 mm. As a rule, active symptoms such as precordial distress, vertigo, and headache disappear in many cases within a few days."

"Where radium solutions per os alone are given, my dosage starts at 6 micrograms per day in three doses; this to continue for four weeks as a rule, then to follow at 6 micrograms per week for the balance of the course. This plan of treatment does not give as uniformly good results as a course inaugurated with an intravenous injection. The plan of insisting on the long time treatment was arrived at, owing to the fact that after the initial drop in pressure, or within five days, the patients generally felt so much improved that there was a tendency to discontinue treatment. It was necessary to make it clear that the early relief had nothing to do with the permanency of the effect most to be desired. In dealing with a disordered metabolism of long standing it would be unwise even to assume that radium would accomplish the impossible. Patience and real radium with or without a portion of psychology are necessary factors to the successful administration of those cases. In your mind will naturally arise the question, what of the permanency of such treatment. To this I can reply that fully three-fourths of the cases have held without further treatment for from six to twelve months. There are many of the early cases treated nearly two years ago that have suffered no material rise. Others where pressure has gone up sufficient to produce symptoms have been quickly touched up with a two or three weeks' treatment. Some of these returned with their trouble on account of growing bold with their diet. An interesting feature in a large number of my cases has been an activation of sexual powers. Insomnia and nervous symptoms are improved and the patients invariably take on a feeling of well being."

"Compensatory functions can be sustained and greatly improved at times with extremely low dosage of radium. In such cases we may observe both systolic and diastolic pressures slowly coming down in a fairly even proportion. Although I can find no record of any unfavorable action following the administration of the soluble salts of radium, I would naturally urge caution in attempting sudden reductions in compensatory high pressures. Here must come a full understanding as to the type of compensation. For the purpose of this paper I have intentionally refrained from dealing with compensatory cases and my selection has been in a measure confined to those types showing relatively a high systolic and a low diastolic pressure. In a series of 135 cases classified, the average systolic pressure was 190 and the average reduction showed at 40 mm.

"The following case histories, selected from the group, although reported with limited detail, I trust will serve to illustrate everyday types with results that should be indicative. Almost all of these cases had received general treatment for a greater or lesser period and were classed as well advanced. In the entire series there were but eight cases that failed to respond and three of these were single-treatment patients. Several of the cases herein reported are one-treat-

ment types. Such a method, without follow-up dosage, is not advised, but the final results are none the less interesting."

"There is an opportunity of vast importance here waiting for the real research worker to pick up the thread and trace the terminal activities and results as they may relate to the physiochemical properties of radium in catalysis and autolysis. Beyond giving treatment to the active case, we are now called upon to give attention to those measures of prevention which will enable those advancing to the fifth and sixth decade to grow old gracefully."

"Case I.—Mrs. R. H., aet. 67. Previous history one of health. Called for treatment following prolonged spell of vertigo—thought by family to be a slight stroke—pressure 220 mm. Had complained of distress around heart. No compensatory influences. Brisk cathartic followed by 50 mcgm. radium intravenously. Twenty-four hours later pressure 180 mm. Four days later back to 200 mm. A second injection of 50 mcgm. given on tenth day reduced pressure to 175 mm. Under the influence of 6 mcgm. per week in divided doses for eight weeks pressure fluctuated between 160 mm. and 170 mm. It is interesting to note that the patient's waist measurement after ten weeks had reduced seven inches."

"Case II.—Mr. P. R., broker, aet. 58. Suffered from trifacial neuralgia for eighteen months. Had received all treatments including injections of alcohol in the nerve sheath. Pressure 175 mm. Limited arteriosclerosis, nervous, loss of memory, exceedingly poor digestion, excessive intestinal fermentation. Two injections five days apart of 50 mcgm. each were given. Final pressure taken four weeks after first injection showed 140 mm. Pain subsided to the point of almost entire freedom. However, during the eighteen months that have passed at times there is a slight tinge of pain that reminds him that there is still some small influence at work."

"Case III.—Mrs. L. M., aet. 50. History of chronic nephritis of ten years' standing. Cardiac hypertrophy. Blood pressure 200 mm. Marked edema of lower extremities, shortness of breath. Had been on rigid diet for five years. Headaches constant. Rheumatoid pains and some arteriosclerosis. This patient was treated with radium solutions, for drinking only, on a dosage of 2 mcgm. t.i.d. for ten days, then 2 mcgm. per day for two weeks. But little influence was shown on the pressure for nearly three weeks, although the patient's breathing was much improved and the edema was less. Increased her exercise. Treatment was carried on for ten weeks longer on a dosage of 6 mcgm. weekly and then discontinued. Gradual decrease in pressure to 170 mm. Six months have elapsed and patient has had no disturbing symptoms."

"Case IV.—Mrs. M., aet. 60. Pressure 180 mm. Consulted for arteriosclerosis in early stage. Characteristic symptoms. Had had operation for gall-bladder trouble. Years of gastrointestinal fermentation. Radium solution only advised. In five weeks took 102 mcgm. of radium. Discontinued on account of marked general improvement in vitality. Digestive processes improved."

"Case V.—Mr. T. S., literary man, aet. 67. Pressure 165 mm. Evidence of early arteriosclerosis, insomnia, precordial distress, with evidences of cardiac load; exhaustion on slight effort. On request was placed on radioactive waters in dosage of about 15,000 mache units daily. After three weeks reported with great improvement. Com-

plexion clear, eyes bright, ready for exercise and remarked that he did not know he had a heart. Pressure reduction about 15 mm."

"Case VI.—Mrs. E. B., aet. 61.—Had suffered from neurasthenia more or less for eight years. Had been treated for "nervous heart." Commonly complained of much gas formation after eating. Pressure 170 mm. Pulse 90. Heart slight hypertropied. Complained of smothering sensation over heart. Rheumatic tendency with a borderline on gout. Intravenous treatment could not be given. Under administration of 28 mcgm. per week in form of drinking solution most of the troublesome symptoms disappeared, but up to the fifth week, when all treatment was discontinued, there was practically no change in the blood pressure."

"Case VII.—Mrs. E., aet. 67. Rheumatoid arthritis. Case of advanced stage. Pressure of 175 mm. Arteriosclerosis advanced with all active symptoms, most trouble asthmatic tendency, on rigid diet. Had received treatment at all the noted spas with only temporary relief. Compensation poorly officiating. Radium solutions in low dosage by mouth relieved respiratory symptoms and improved precordial distress to some degree. On advancing the dose to 6 mcgm. daily, after ten days' reaction in the rheumatoid processes presented. This pain seemed to activate her other troubles. All treatment discontinued for ten days. Treatment renewed on small dosage of 2 mcgm. daily and again relief was obtained. No action whatever on the blood pressure could be observed."

Case VIII.—Mr. J. M., broker, aet. 62. Systolic pressure 180 mm. under observation and treatment fifteen months previously. Case presents symptoms of vertigo, precordial distress, insomnia, etc. Gastro-intestinal fermentation prominent. Recently developed nephritis. Administered by intravenous method 50 mcgm. radium July 12. Pressure July 14, 150 mm. Improved respiration noted. July 18, 25 mcgm. radium intravenously, followed three times weekly with 2 mcgm. radium in distilled water per os. September 2, systolic 140 mm. All physical symptoms relieved. Urine showed no albumin or casts."

"October 10 patient discharged pressure 150 mm."

"Case IX.—Mrs. D., aet. 57. Pressure 210 mm. General arteriosclerosis with all symptoms. Had been a very active woman; had to cease all occupation for the last eight months. General treatment influenced the hypertension only temporarily and gave little improvement in symptoms. One injection of 50 mcgm. given intravenously; pressure came down 30 mm. during the next twenty-four hours. At the end of three weeks, pressure had settled at 188 mm. and all symptoms had disappeared. General health very good and could do all work she used to do ten years ago. Reports a year after the injection that she is in fine shape. Pressure 185 mm."

Case X.—Professor, aet. 50. Violent headaches for the last six years. Had to stop his lectures frequently. All functions disturbed, specially digestion. Wassermann negative. Arteriosclerosis with blood pressure of 230 mm. General intestinal fermentation. No other known cause. One injection of 50 mcgm. radium element given at 12 noon. Pressure down to 200 mm. at 6 P. M. Four weeks after injection patient has pressure of 176 mm. and says that he never felt better; has the sensation of having much smaller weight of body. Attends to daily work regularly and a year after the injection is in very good health."

"Case XI.—R., butcher. Consulted for general malaise, headache, vertigo, etc. Blood pressure 200 mm. One injection of 50 mcgm. reduced the pressure to 180 mm. in seven hours. Had 165 mm. at the end of three weeks. Varies from 160 mm. to 165 mm. at the end of eighteen months. Patient in very good health."

"Case XII.—Mr. W., aet. 72. Suffering from trifacial neuralgia for the last eleven years. General health fairly good. Blood pressure 220 mm. One 50 mcgm. ampulle injected at 3 P. M. Next morning pressure was 180 mm.; three weeks after the injection shows 175 mm. to 180 mm. and stayed at this mark since that time (a year and a half). Most surprisingly, the neuralgia disappeared almost completely soon after the injection and has not reappeared since."

"Case XIII.—Butcher, aet. 60. General rheumatic condition for the last twenty years. Blood pressure 190 mm. One 50 mcgm. radium injection reduced the pressure to 160 mm. in four days and it settled at 150 mm. at the end of a month. Patient in absolutely good health at the end of a year."

"Case XIV.—Mrs. C., aet. 50. Subacute rheumatism. History of either neuritis or rheumatism for the last two months. Pressure 200 mm., following the administration of 50 mcgms. radium element intravenously, reduced in five days to 160 mm. and 150 mm. after three weeks. All rheumatic symptoms disappeared completely in about ten days. Reports in very fine health after a year; pressure 160 mm."

"Case XV.—Mrs. R. P., aet. 50. Suffering from neuritis for the last six years. Could not sleep more than an hour in the night. Pain in the left arm, and from base of skull down to the lumbar region almost constantly. Blood pressure 205 mm. No form of treatment produced any noticeable change either of the neuritis or blood pressure. Injected 50 mcgm. radium element intravenously. Pressure 180 mm. the next day—170 mm. at the end of three weeks. Pain almost gone except in a small spot at the base of the skull. Second injection caused the pain to disappear completely in twelve days. Patient reports every month. At the end of a year no pain had recurred—patient can sleep from ten to twelve hours every night and take a nap in the afternoon; has gained thirty pounds and says she feels twenty years younger."

"Case XVI.—Mr. W., coal dealer, aet. 65. Blood pressure 230 mm. Violent headaches, dizziness, advanced arteriosclerosis. No improvement under any form of treatment for the last ten years. One 50 mcgm. injection of radium element lowered the pressure 50 mm. in a period of four weeks. A year from the injection patient has pressure of 175 mm. and has had no recurrence of his former symptoms."

"Case XVII.—Mr. S., aet 72. General arteriosclerosis. Complained of feeling heavy together with a general sensation of malaise and anxiety. Rheumatic pains for the last twenty years, subacute attacks more frequent and compel him to stay in bed about once every two months for a period of one to two weeks. Blood pressure 240 mm. One injection (50 mcgm. radium element) brought the pressure down to 190 in five days. All rheumatic symptoms had disappeared in four weeks. Patient reports every month and is very grateful to radium treatment. After the period of a year no symptoms have reappeared and the general condition is very good—blood pressure 190 mm."

"Case XVIII.—B., aet. 45. General condition bad; no other symptoms except increasing weakness, loss of weight and anxiety; almost constant headache. Blood pressure 260 mm. reduced to 210 mm. in

four days with an injection of 50 mcgm. radium element; 200 mm. in seven days. Patient reports often and at the end of six months has gained thirty pounds, feels fine and pressure is 180 mm."

"Case XIX.—Failure. Patient with pressure of 230 mm. General malaise, but not sufficient to prevent him working. Visited the best clinics for the last two years. Failed to reduce the pressure with diet, treatment, etc. 50 mcgm. radium element in the form of an intravenous injection reduced pressure 11 mm. in six hours. Next day pressure went back to 230 mm. There is no trouble with the kidneys or with the circulatory system. Opportunity for further treatment with radium was not possible. Simply a case of idiopathic hypertension and possibly would not have been influenced."

"Case XX.—Mrs. L. S., housewife, aet. 59. Marked depression with melancholia. Three members of her family died of apoplexy. Severe vertigo, insomnia, asthmatic tendency, abdominal distention, fairly advanced arteriosclerosis with nephritis, anemic; hemoglobin 70 per cent. Pressure 180 mm. In this case 50 mcgm. radium was given intravenously. Ten days later pressure 160 mm.—symptoms somewhat relieved. A second injection, 25 mcgm., was given resulting four days later in a pressure of 145 mm. Two weeks later pressure was found to be at 160 mm. Radium solution in doses of 2 mcgm. ordered every day. Pressure taken twice weekly for six weeks of this treatment showed an average of 155 mm. Nephritis cleared up. Asthma disappeared, deep respiration, patient less nervous and rested well, took up her housework with renewed interest."

"In conclusion may I leave just one thought with you; I would have you agree with me that we are dealing with a most potent force, remarkable in its powers to activate biochemical processes. It is commended to you only as an adjunct, to be used in conjunction with all remedies recognized as effective in influencing metabolism."

"But few of my friends here tonight have ever listened to a paper on the theme of your president's choice— to my knowledge, it is the first time in this country that the subject has been presented. Radium in this field, received even as its introduction a startling statement, for in a very recent issue of the Medical Record an authority unhesitatingly proclaims as follows: 'The greatest enemy of the cardiovascular-renal patient is the supposed specific, whether it be electricity, radium, etc." How science must hold its head low and weep, or shall I say smile? In my early days of practice I remember my antagonism to diphtheria antitoxin. Quinine was almost lost in a veil of ridicule. Chloroform had its hard fight for recognition, and even today you will hear of the unbelief in salvarsan, so we can be both charitable and patient. If you assume that I have erred in conservative expression let the excuse be that the worker in radium therapy grows enthusiastic as he manipulates that agent of greatest known energy, the product of the Almighty's laboratory, 'Mother Earth.'"

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Guy C. Boughton, M.D. (Erie). The Treatment of Cancer by the Use of Radium in Conjunction with Surgery. Penna. Medical Journ., Vol. XIX, pp. 277-80, Jan., 1916.

"Most of the cases of cancer, in which radium treatment has been used, have been inoperable cases, many almost moribund, and in this type of cases radium treatment has achieved what no other treatment could do. As a palliative it has relieved the pain, stopped the discharges, and done away with the foul odor, conditions, which make the last days of a cancer sufferer, as well as those who may be near, almost unendurable. Radium has brought relief in hopeless cases and a peaceful end. More than this it has removed the local growths in many cases and has brought about clinical cures. As in surgery, only the test of time can tell whether a real case cure has been effected."

"Surgery offers no hope in advanced cancer cases, particularly where metastases have formed. In such conditions we are forced to turn to other methods of treatment and in many cases radium with the hard X-rays, or radium with surgical procedures have done much to relieve and, in some instances, to remove the malignant growths."

"The value of radium is not established by one success, nor does one failure prove its lack of value. Yet there are many who condemn radium for its failure to effect a cure in all cases (most of them hopeless before they turn to radium). On the other hand there has been the over enthusiasm of those who have worked carefully with adequate amounts of radium and have noted its wonderful results. The remarkable results which radium has been able to produce in apparently hopeless cases, have been the pardonable cause of this enthusiasm. That radium is of definite value in the treatment of certain types of malignant growths is well established. Like all other agents it has its limitations, and it is far from being a panacea."

"For the present cancer can be considered as curable only when it can be removed from the body. Just now there is a great wave of publicity sweeping this country, with the object, if the cancer is to be checked and destroyed, of bringing to people's attention the necessity for early operative measures. This work will be of great value, but in spite of it we will continue to have malignant growths to treat, and when one considers the enormous number of people dying each year as a result of cancer, it is easy to realize that surgery alone will not suffice for the treatment of cancer."

"We must bring to bear all the forces at our command, if we are to be successful in the conquest of cancer, and for this reason I would like to call your attention to the greater value of surgery plus radium as treatment for many forms of malignancy."

"Successful surgical treatment has as its basis the complete removal of all the malignant growth. This is only possible where the growth is local, and conditions permit of its complete removal. Who has not seen cases that have been hastened to a fatal end by faulty operative measures or an epithelioma on the lip or tongue which after operation has extended rapidly through the glands of the neck? Yet one does not condemn all surgical proceedures on this account."

"The basis of the action of the radium rays is a selective destructive effect of the rays upon malignant tissues, the same dosage of rays not producing the destructive effect on the adjacent normal tissues. Histological studies have shown conclusively that there is this selective effect of the rays. Therefore, radium rays are not to be classed with the caustics and the cautery which destroy all tissues with which they come into contact. Histological studies have also shown the protean

character of malignant neoplasms. This branch of pathology is like a fourth dimension of medicine and surgery. We are grappling in the dark with problems beyond our comprehension, and in such cases we are forced to be empirical, and conservative. Yet our advance is hindered by our empiricism and conservatism."

"When the value of any method is generally recognized, then it is hard to convince people that anything is even better. The value of surgery in cancer is unquestioned, and yet on the whole, is there not room for much improvement?"

"Radium therapy for more than superficial conditions dates back to less than a decade, and even now the technic of radium therapy is still far from being finally determined. It has been only within the past three or four years that radium has been used in larger quantities with the heavy screening to cut off beta rays. The international radium standard has been established for several years, so that it is possible for workers to know exactly what they are working with. When you consider that there is probably less than 60,000 milligrams (about two ounces) of radium element in all the radium preparations in the world, and that a large proportion of this radium has been in use for only a brief time, and that the bulk of this radium is in the possession of a few institutions or individuals, you can begin to realize that we are just at the threshold of the knowledge of radium therapy. Now radium preparations may be secured, having definite radium content, and this marks a great step in the fixing of a technic of radium therapy. The next advance can come when statistics are made available, showing the results of radium treatment and the duration of improvement. At present there are only a comparatively few workers in the field of radium therapy, and many of us have not as large amounts of radium as would be desirable, so that the number of cases that can be treated at one time is necessarily limited. However, it is out of the total of such work that the final judgment as regards radium therapy is to come, and I take this occasion to present some reports that have come out of my personal experience in the use of radium in combination with surgical treatment, in cases of malignant growths."

"Case 1. Mrs. J. C., aged forty-seven years, married. Diagnosis: medullary carcinoma of cervix. Father and mother were alive and well; also four brothers and three sisters. Patient had diphtheria fifteen years previously and measles ten years previously. She had had two children. Urinalysis: Urine cloudy, amber, acid, specific gracity 1.009, negative for glucose, trace of albumin, many epithelial cells and few leukocytes. Blood: May 11, 1915, hemoglobin, 39 per cent.; red blood corpuscles, 3,840,000; leukocytes 12,000, June 20, 1915, hemoglobin, 52 per cent.; red blood corpuscles 3,860,000."

"November, 1914, patient began to have uterine hemorrhages; this condition continued for nine weeks and discharge began to have offensive odor. On Jauary 4, 1915, patient had a large polypus removed and in February a supravaginal hysterectomy was performed for fibroid uterus. May 10, a large sloughing mass was removed from cervix which was cauterized. Radium treatment began May 12, 1915, and patient had 7395 milligram hours of treatment. She was discharged as clinically cured, August 14, 1915."

"Case 2. Mrs. J. E., aged sixty-five years, married. Diagnosis: Carcinoma of vagina. Father died of old age; mother died at the age

of fifty-eight years with liver trouble; one sister was at Warren asylum and three sisters and two brothers were alive and well. Patient had had the diseases of childhood."

"At the beginning of November, 1914, patient noticed, off and on, a slight flowing with no pain. At the end of November, her physician, upon examination, advised immediate operation. December 3, 1914, the patient was operated upon by Dr. George Reed who performed a complete hysterectomy. Radium treatment was begun March 3, and the patient had 5590 milligram hours of treatment. Discharged as clinically cured May 28, 1915."

"Case 3. Mrs. P. E., aged forty-one years, married. Diagnosis: Carcinoma of breast. Father was alive and well; mother died of pneumonia at the age of sixty; one sister and one brother were alive and well. Patient had had the diseases of childhood.

"About November 1, 1914, patient noticed a soreness of left breast. Complete removal of breast was performed December 1, 1914. Urinalysis was negative. Radium treatment was begun March 22, 1915, and patient had 4520 milligram hours of treatment. She was discharged as clinically cured August 15, 1915."

"Case 4. Mrs. A. W. W., aged sixty-two, widow. Diagnosis: Carcinoma of breast. Father died of heart trouble, aged sixty-two; mother died, aged seventy-eight, cause of death unknown. Patient had had the diseases of childhood."

"About December, 1914, patient noticed a lump in left breast; she suffered severe pain in breast and down left arm up to time of operation. Complete removal of breast was performed February 4, 1915. Radium treatment was begun March 15, 1915, and up to August 6 patient had 4288 milligram hours of treatment."

"In conclusion, I wish to emphasize that what is necessary now is co-operation rather than destructive criticism, if we are to be able to establish the value of radium therapy in the treatment of malignant growths. Those who pioneer in any field have and expect to have hard work before them. The days of pioneering in work with radium are far from being past, yet this agent has been demonstrated and is being accepted more and more widely as a most valuable adjunct to the older methods of treatment. We would not replace surgery by radium therapy, but rather, by combination with radium therapy, make surgery more effective. The surgeon can remove the greater part of the malignant tissue, but the radium rays in suitable cases can go in and destroy all of the remaining malignant cells, and in the treatment of even inoperable superficial cancers, carcinoma of the uterus, the prostate, the rectum, and the breast, and in spindle-celled, round-celled sarcoma, lymphosarcoma, in rodent ulcers, radium has been shown to be of definite value, and the future will rather add than subtract from our present estimate, as the work goes on, and the amount of radium available increases."

"NOTE: After the report of Case 2 was given before the state society, the patient had a sudden recurrence of the disease in the large bowel and subsequently died."

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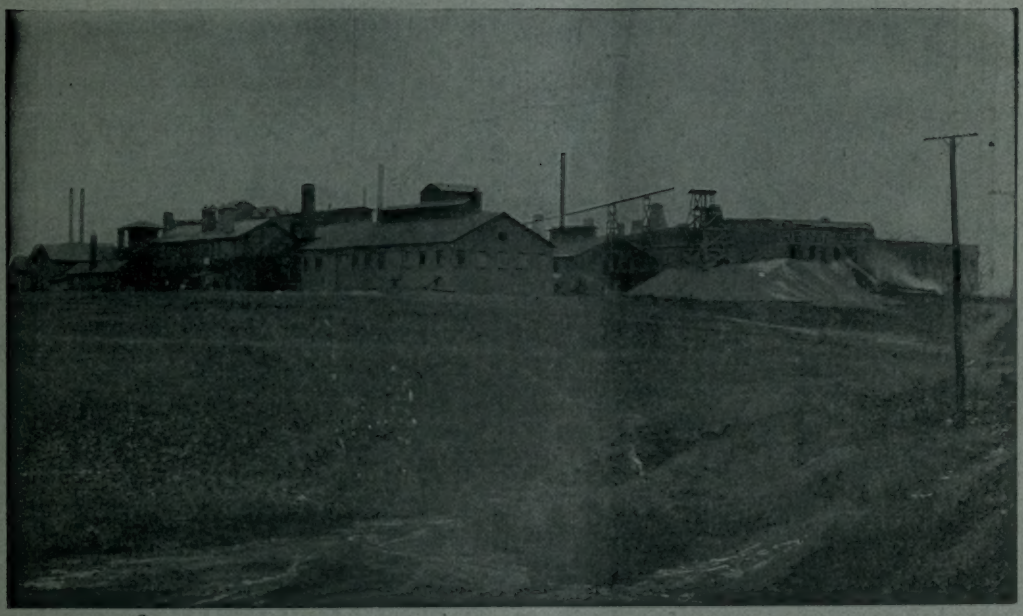

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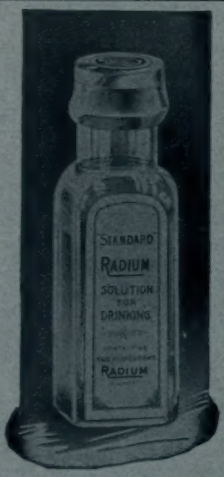

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Maximum-equilibrium constant of radium emanation, 5400 mache units.

PERMANENT

"Standard" Radium Solution for Intravenous Use.

—

In Ampulles of 2 cc. N. P. S. S. containing 5, 10, 25, 50, or 100 micrograms radium element.

PERMANENT

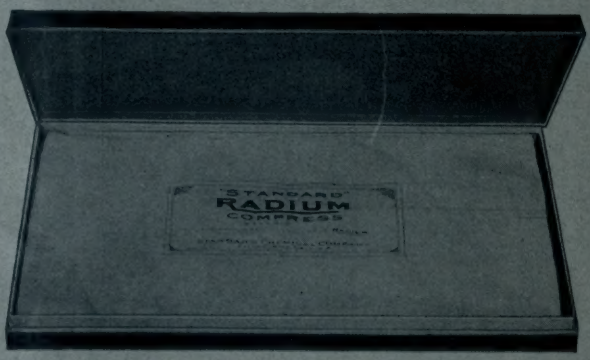
"Standard" Radium Compress

—

A means of applying radium locally for the relief of pain.

—

A flexible pad of standardized, guaranteed radium element content.



PERMANENT RADIO-ACTIVITY

INDICATIONS

Subacute and Chronic Joint and Muscular Conditions.
High Blood Pressure. Nephritis.
The Simple and Pernicious Anemias.

"The value of radium is unquestionably established in chronic and subacute arthritis of all kinds (luetic and tuberculous excepted), acute, subacute and chronic joint and muscular rheumatism (so called), in gout, sciatica, neuralgia, polyneuritis, lumbago and the lancinating pain of tabes."—Rowntree and Baetjer, Journal A. M. A. Oct. 18, 1913.

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